Litton Systems
MOD007152903
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10-12-88

JOHN ASHCROFT
Governor

FREDERICK A. BRUNNER
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

MEMORANDUM

30289706

DATE: October 12, 1988

TO: Chuck Kroeger, DEQ, Springfield

FROM: Charles Williams, DGLS, Rolla C.E. Williams

SUBJECT: Litton Industries PA/SI Site

Enclosed is the geohydrologic information required for the Documentation Records for Hazard Ranking System, and Part 5 of the Potential Hazardous Waste Site - Site Inspection Report for the subject site.

The Litton site is within a 4-5 square mile internally-drained area northwest of the Springfield City limits (See map included as reference 3). Within this sinkhole plain, all precipitation enters the groundwater system in one way or another. Much of the precipitation enters sinkholes, which funnel water like a storm-sewer system to spring outlets to the north and east. A significant amount of precipitation percolates through the permeable residual soil to the top of the pinnacled bedrock. These laterally discontinuous perched water zones provide base flow to the area springs by slowly releasing the groundwater to solution-enlarged conduits. A minor amount of the precipitation that falls on the area, possibly an insignificant amount, bypasses the karst drainage system and recharges the regional Mississippian Aquifer below the vadose zone.

When heavy and/or prolonged precipitation occurs at the Litton site, surface flow drains predominantly to a sinkhole in the northeast corner of the Springfield Municipal Airport. An artificial drainage channel has been constructed along the eastern side of the airport, which empties into the broad, shallow "Airport Sink". This was done to prevent ponding of water around the northeast runway. The southeast part of the Litton site is drained by a sinkhole on the other side of the companys' east property line. Fluorescein dye was injected into the Airport Sink after a heavy rain, and the dye was recovered at Williams, Fantastic Caverns, and Bunge Springs to the north-northeast (see reference 3). During low flow conditions, these springs function independently of each other, as shown by the results of other dye injections during dry weather, but in high flow, they appear to overflow and commingle with each other.

A dye trace has not been attempted from the sinkhole that drains the southeast corner of the site. Based on the Mono Mfg. dye trace, however, fluids entering this sinkhole would be expected to travel to Ritter West Spring to the northeast. A dye trace will be attempted from this sinkhole sometime this winter. The zone between the Litton Site and the Airport Sink is a grey area. This area may recharge the northern springs, or Ritter West spring. It is an area of significant perched water, at the residual soil/bedrock interface. I don't have any information on the monitoring wells that were adjacent to the old process lagoon, but I expect that they were drilled to refusal (bedrock), and monitored this discontinuous perched zone.

Properly cased water wells downgradient of the site should be unaffected by the contaminants originating there. Even poorly cased wells (those that are open to at least part of the vadose zone) are marginally susceptible to being contaminated from the Litton site because the chances of intercepting a solution-enlarged conduit are relatively small. Wells completed in the Ordovician aquifer and cased below the Northview confining unit are in no danger of being contaminated from the Litton site.

DOCUMENTATION RECORDS FOR HAZARD RANKING SYSTEM

PAGE 1

Location: SE 1/4, SW 1/4, Sec. 6 (measured from bottom of long section), T. 29 N., R. 22 W., Brookline Quadrangle.

PAGE 2

Name/description of aquifer(s) of concern:

There are two aquifers of concern here. The upper aquifer is composed of all bedrock units above the Northview aquitard, predominantly limestone and cherty limestone. This aquifer is highly susceptible to contamination due to its proximity to the surface and the high degree of solution weathering it has been subjected to. The yield from this aquifer is highly variable (1-50 gpm), depending on depth of penetration of the aquifer and the amount of secondary permeability features intercepted by the wellbore. The lower, or major aquifer, is separated from the upper aquifer by the 25-30' thick Northview Formation, which is mainly shale, with minor siltstone. This thick aquifer is composed of dolomite and sandstone, and is recharged almost entirely from precipitation falling on its outcrop area to the east on the Salem Plateau. A minor amount of recharge from the overlying upper aquifer does occur because of the head differential between the two aquifers. Wells open to the entire sequence are capable of producing 1000-2000 gpm. The major aquifer is not susceptible to contamination from local sources unless poorly cased water wells are present that provide an avenue of contaminant transport. (Reference 1).

Depth(s) from the ground surface to the highest seasonal level of the saturated zone [water table(s)] of the aquifer of concern:

Estimate 75' to saturated zone in upper aquifer. The top of the lower aquifer is about 300' below the surface. The water level in a well completed in the lower aquifer would rise 25-50' above the top of the aquifer due to its confined condition. (Reference 1)

PAGE 3

Soil type in unsaturated zone:

Red cherty clay residual soil. (References 1, 2, 6)

Permeability associated with soil type:

0.6-2.0 inches/hr. (10^{-3} to 10^{-4} cm/sec.) (Reference 2)

Average slope of facility in percent:

2-3% (Reference 3)

Name/description of nearest downslope surface water:

The entire Litton site is internally drained by sinkholes, which do not hold water except after very heavy rains. Most of the site drains to the northwest toward the airport. Surface flow from the Litton site which enters the airport property is conveyed by artificial drainageways to a broad, shallow sinkhole just northeast of the NE-SW runway. This sinkhole fills with storm water after a heavy rain, but loses it through the bottom within a day or two after the rain stops. Fluorescein dye placed in this sinkhole after a 3" rain on August 22, 1988 traveled to Williams, Fantastic Caverns, and Bunge Springs to the north-northeast. Another sinkhole is located just east of the Litton property that drains the southeast corner of the site. A dye trace has not been attempted from this sinkhole, but it is believed that dye injected there would travel to Ritter West Spring. The Litton site is apparently near the recharge area boundary between Williams Spring and Ritter West Spring. These springs are the nearest donwslope surface water from the site. Williams and Ritter Springs are fairly consistent in their flow volume, ranging between 1-10 cfs approximately, depending on weather conditions. Bunge Spring has a similarly consistent flow, although only one-third as large. Fantastic Caverns Spring has a highly variable flow, and is apparently the "relief valve" spring in the Williams-Fantastic-Bunge complex. Its discharge ranges from almost nothing to 50 cfs or more. (References 4, 5)

Average slope of terrain between facility and above-cited surface water body in percent:

Elevation of site 1280'
Elevation of "Airport sink" 1250'
Elevation of east sink 1260'
Spring elevations
- a) Ritter West 1125'
- b) Williams 1070'
- c) Fantastic Caverns 1070'
- d) Bunge 1090'

Average slope of terrain between:

a) Site and Airport Sink $\frac{1280-1250}{4000'} = \frac{30}{4000} = 0.75\%$

b) Site and East Sink $\frac{1280-1260}{600'} = \frac{20}{600} = 3.33\%$

c) Airport Sink and Williams Spring $\frac{1250-1070}{14800} = \frac{180}{14800} = 1.22\%$

d) Airport Sink and Fantastic Spring $\frac{1250-1070}{14400} = \frac{180}{14400} = 1.25\%$

e) Airport Sink and Bunge Spring $\frac{1250-1090}{14000} = \frac{160}{14000} = 1.14\%$

f) East Sink and Ritter West Spring $\frac{1260-1125}{14800} = \frac{135}{14800} = 0.91\%$

(Reference 3)

Is the facility located either totally or partially in surface water?

No. (Reference 6)

PAGE 7

Is the facility completely surrounded by areas of higher elevation?

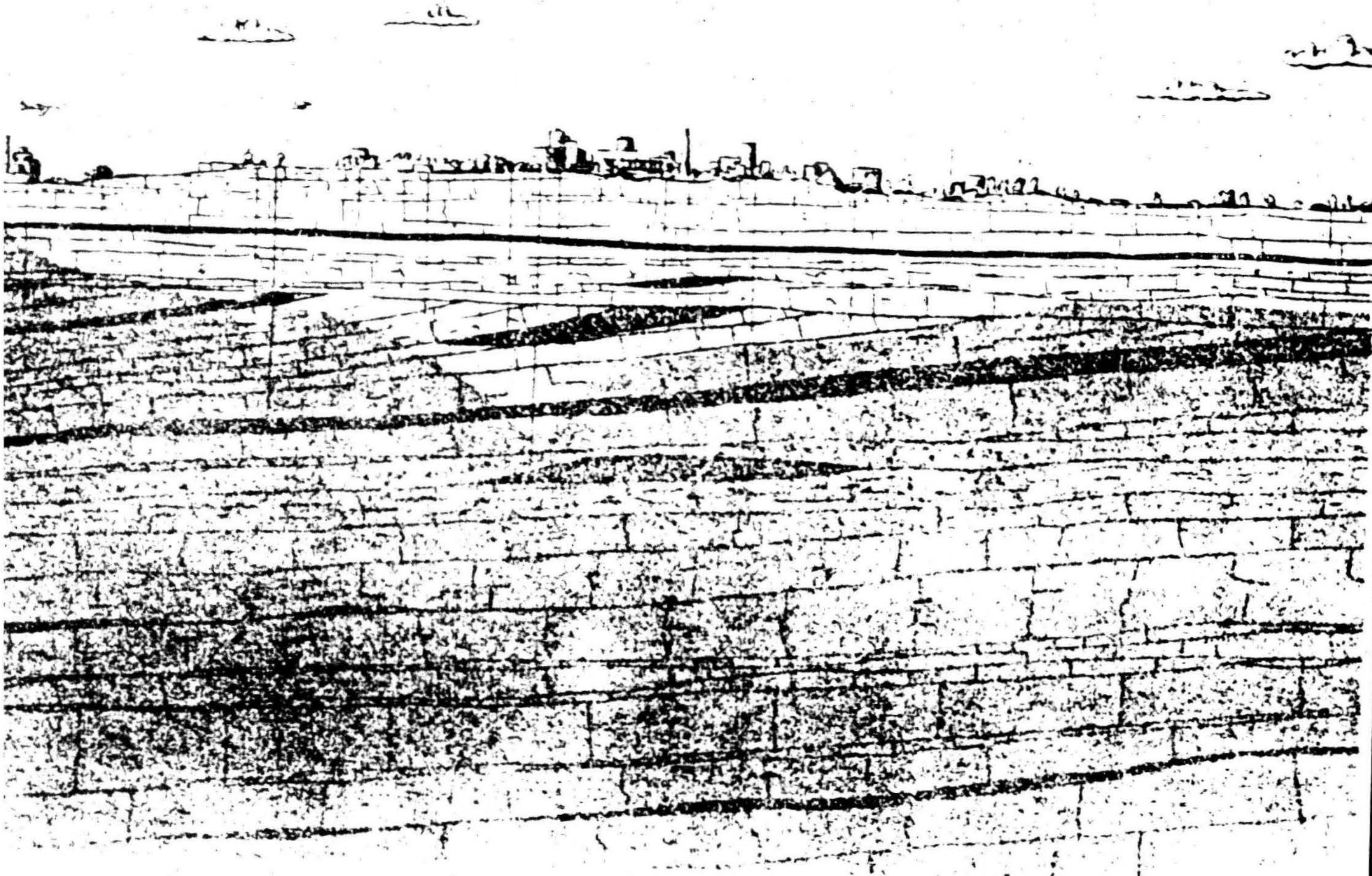
Yes, the entire site is internally drained by sinkholes. (References 3, 4, 6)

REFERENCES

Reference Number	Description of Reference
1	Water Resources and Geology of the Springfield Area, Mo., Water Resources Report No. 34, by Leo F. Emmett, etal, a DGLS publication, 1978.
2	Soil Survey of Greene and Lawrence Counties, Missouri; USDA, SCS, 1982.
3	Brookline, Willard, Ebenezer, and Springfield 7 1/2' Topographic Quadrangles, USGS, 1960, photo-revised 1970 and 1975.
4	Dye Tracing in the northwest Springfield area by C. E. Williams and Ben Pendleton.
5	Springs of Missouri, Water Resources Report No. 29, by Jerry D. Vineyard and Gerald L. Feder, a DGLS publication, 1982.
6	Site visits by C.E. Williams, August 13, 1988.

WATER RESOURCES REPORT NO. 3

WATER RESOURCES AND GEOLOGY OF THE SPRINGFIELD AREA, MO



WATER RESOURCES REPORT NO. 34

1978

WATER RESOURCES AND GEOLOGY OF THE SPRINGFIELD AREA, MISSOURI

WATER RESOURCES
By Leo F. Emmett, John Skelton, R. R. Luckey, and Don E. Miller

AREAL GEOLOGY
By Thomas L. Thompson

ENGINEERING GEOLOGY
By John W. Whitfield

Prepared under a cooperative agreement between

GEOLOGY AND LAND SURVEY DIVISION, MISSOURI DEPARTMENT OF NATURAL RESOURCES
Fairgrounds Road, P.O. Box 250, Rolla, MO 65401

WATER RESOURCES DIVISION, U.S. GEOLOGICAL SURVEY
Rolla Center, Mail Stop 200, Rolla, MO 65401

Table 4

GENERALIZED SECTION OF GEOLOGIC FORMATIONS IN THE SPRINGFIELD AREA*

SYSTEM	SERIES	GROUP	FORMATION	THICKNESS (FT.)	LITHOLOGY		HYDROLOGIC CHARACTERISTICS
QUATERNARY	Pleistocene and Recent		RESIDUUM AND ALLUVIUM	0-30'	*Residuum* - silt, clay, soil, chert fragments. *Alluvium* - silt, clay, fine grained sand		Not important as an aquifer in the study area
PENNSYLVANIAN	Desmoinesian		WARNER FORMATION	0-95	Sandstone and conglomerate, very irregular in distribution and thickness		Not important as an aquifer in the study area
MISSISSIPPIAN	Meramecian		WARSAW FORMATION	40-60	Fine to coarsely crystalline, slightly cherty limestone		Not important as an aquifer in the study area
	Osagean		BURLINGTON-KEOKUK LIMESTONE	155-270	Medium to coarsely crystalline limestone with nodular and bedded chert	Minor Aquifer	This interval yields small to moderate ([illegible] gpm) quantities of water to wells in the study area. Springs are common in this horizon. Water draining from this aquifer maintains dry weather flow of streams. Water is of a calcium-bicarbonate type
			ELSEY FORMATION	25-75	Finely crystalline limestone with abundant nodular and massively bedded chert. In the Springfield area the Elsey Formation rests on the Pierson Formation and is overlain by the Burlington-Keokuk Limestone		
			REEDS SPRING FORMATION	0-125	Gray, grayish-green and red limestone, and green and red calcareous shale. To the south and southwest of the Springfield area the Reeds Spring Formation intervenes between the Pierson and the Elsey		
			PIERSON FORMATION	5-90	*Upper* - Cherty limestone and dolomitic limestone. *Lower* - Massively bedded brown dolomite		
	Kinderhookian	Chouteau	NORTHVIEW FORMATION	0-80	Brownish siltstone and blue to bluish-green shale	Confining Layer	Upper confining layer for major aquifer. Retards downward movement of water from minor (limestone) aquifer to major (dolomite) aquifer
			COMPTON FORMATION	2-30	Finely crystalline to sublithographic limestone		Not important as an aquifer in the study area
			BACHELOR FORMATION	0-5	Greenish quartzose sandstone with calcareous cement		
DEVONIAN	Upper		CHATTANOOGA SHALE	0-5	Dark gray to black fissile shale		Thin isolated occurrences recorded in well records. Not hydrologically significant
			SYLAMORE SANDSTONE	0-5	Sandstone with numerous black phosphatic nodules		
ORDOVICIAN	Canadian		COTTER DOLOMITE	55-355	Dolomite, cherty dolomite, bedded chert, and quartz sandstone	Major Aquifer	This sequence acts as a hydrologic unit in this area. Wells open to the total thickness have been pumped at rates of [illegible] 00 gpm. Water from this aquifer is a calcium-magnesium bicarbonate type
			JEFFERSON CITY DOLOMITE	90-250'			
			ROUBIDOUX FORMATION	140-250			
			UPPER GASCONADE DOLOMITE	40-100			
			LOWER GASCONADE DOLOMITE	235-320			
			GUNTER SANDSTONE MEMBER	25-50			
CAMBRIAN	Upper		EMINENCE DOLOMITE	90-350	Dolomite with small amounts of cherty dolomite		
			POTOSI DOLOMITE	30-[illegible]			
		Elvins	DERBY-DOERUN DOLOMITE	[illegible]	Dolomite interbedded with thin bedded [illegible] and shale	Confining Layer	Probably a confining layer for the overlying dolomite aquifer
			DAVIS FORMATION	140-[illegible]	Shale, siltstone, fine grained sandstone, dolomite and limestone conglomerate		
			BONNETERRE FORMATION	[illegible]	[illegible] grained [illegible]		Probably not important as an aquifer in the study area
			LAMOTTE SANDSTONE	[illegible]	Quartzose sandstone		
PRECAMBRIAN					Igneous rocks		Precambrian is about [illegible] below [illegible]

*The stratigraphic nomenclature used in this report is that of the Missouri Division of Geology and Land Survey and differs somewhat from the current usage of the U.S. Geological Survey.

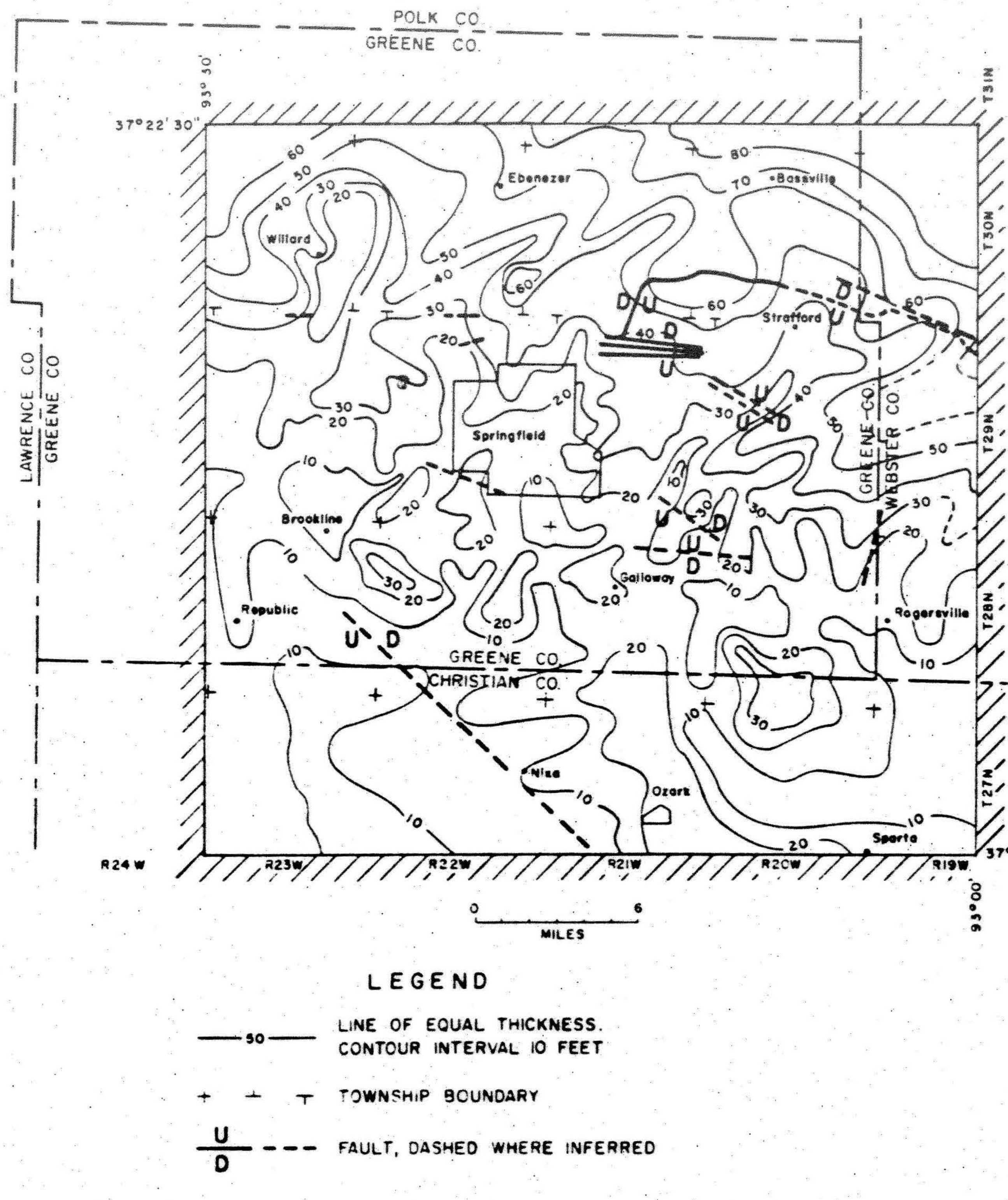


Figure 4

Map showing the thickness of the Northview Formation.

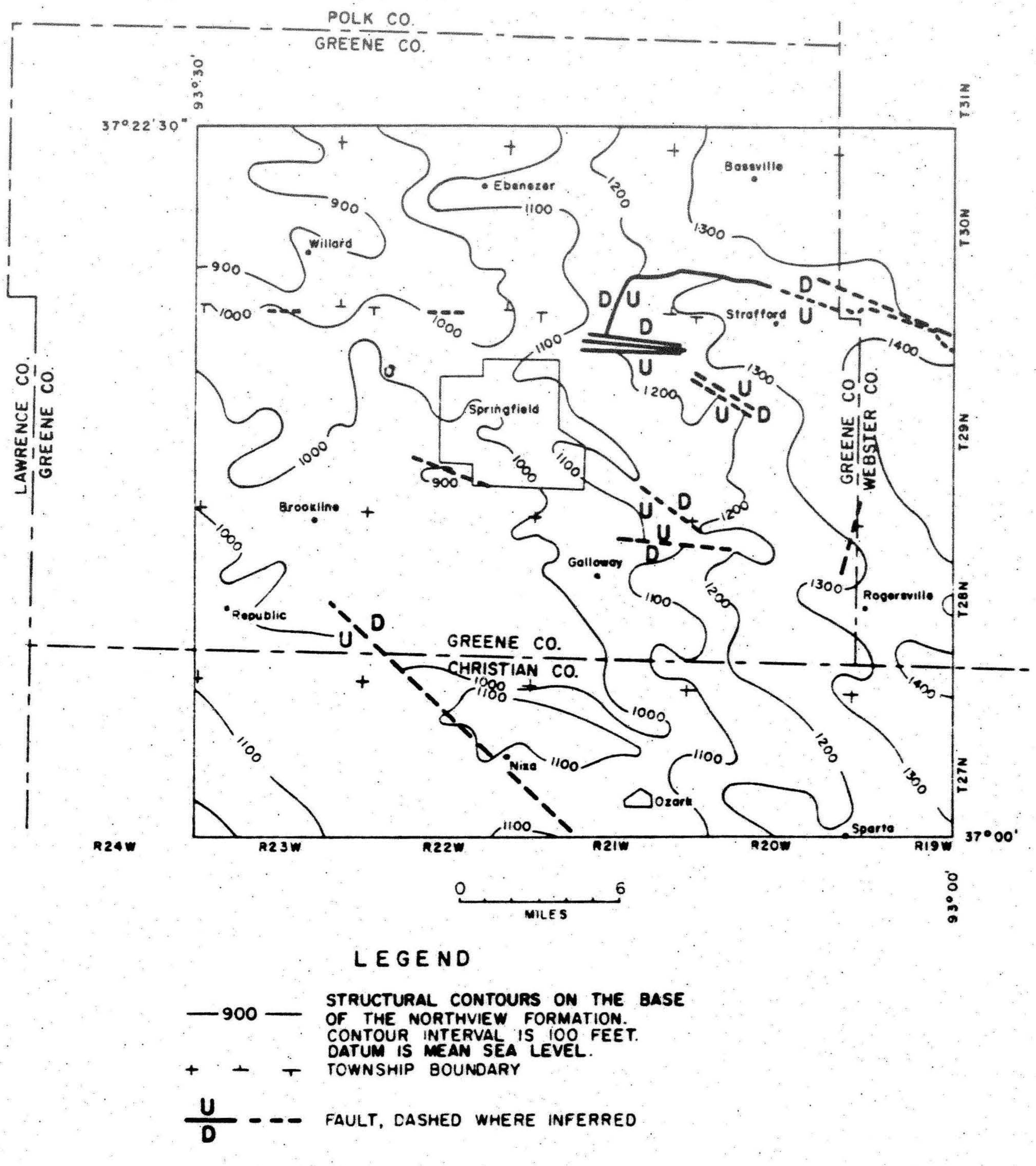


Figure 5

Structure contour map: contoured on the base of the Northview Formation.

To prevent leakage, this red stoney soil should be treated with soda ash or covered with a clay pad. Both sealing methods are costly and success is uncertain.

Small ponds can be constructed in Unit Ul. If at all possible, the pond floor should not penetrate the brown loessial soil. If Unit Ul is thin and it is necessary to expose the underlying red stoney soil in the pond floor then a pad of some sort will be needed to prevent leakage. A compacted clay pad consisting of a half-and-half mixture of brown clay from Unit Ul and red stoney soil can be used. Sometimes the red stoney soil can be sealed by applying a little soda ash (1 pound per 5 square feet) and then disking and compacting the surface of the treated clay.

LAGOONS: This unit is favorable for lagoons. Excavations should be kept to a minimum so that the underlying red stoney soil is not exposed. If the red stoney soil is exposed, remedial treatment will be necessary. If only small areas of red stoney soil are exposed inside the lagoons, the stoney soil can be over-excavated to a depth of 24 inches and replaced with compacted brown clay.

Deep excavations for lagoons require more costly sealing methods to prevent leakage. Remedial treatment can range from a water-tight rubber or plastic liner to a compacted, chemically treated clay pad.

Pinnacled bedrock and voids may be encountered in deep excavations.

Intersector trenches may be needed around the outsides of lagoon excavations to intercept flow from perched water tables.

LANDFILLS: Unit Ul is not favorable for landfills because soils vary in thickness and are generally not thick enough to provide a water-tight base and cover material for landfills.

RECEIVING STREAMS: Receiving streams in this unit are dry most of the year. They are located in the upper reaches of watersheds and do not receive enough surface runoff or recharge from groundwater supplies to maintain a year-round flow.

Small wet weather springs occur in shallow gulleys in the uplands. Early-day farmers valued these small springs as water sources for their families and livestock. Shallow basins made of stone were built at the spring orifices to hold water. Many of these spring orifices are marked by large sycamore trees growing nearby.

UNIT Ur

Uplands with residual soil over weathered limestone (fig. 27).

TOPOGRAPHIC SETTING: Flat to rolling uplands with gentle to moderate

slopes where Unit Ur grades into Unit Sa. Large karst areas; sinkholes, caves, and springs are common. Because of the weathering characteristics of the Burlington Limestone, bedrock pinnacles and residual chert boulders are common.

UNIT THICKNESS: 1-30 feet

SOIL: Soil developed as a residuum from the weathering of the underlying cherty limestone. Soil mantle ranges from red colored clayey soil to layers of chert boulders and gravel containing very little clay. The chert boulders and gravel are formed from the breakdown of chert weathered from the limestone. After the soluble carbonate portion of the limestone has been altered to residual soil the more resistant chert is left "floating" in soil. Layers of residual chert will often retain bedding characteristics of the bedrock, forming undulating horizontal beds of chert situated between soil layers.

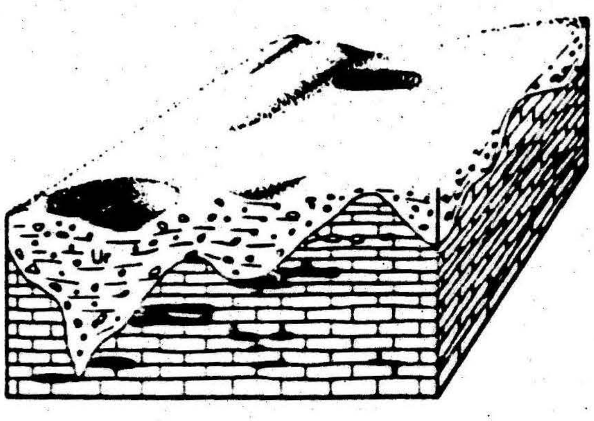


Figure 27
Unit Ur, uplands with residual soil over weathered limestone.

In some places, soil sequences in Unit Ur may be over 10 feet thick and contain very little chert. In other places there will be sequences of chert boulders and gravel layers 1 to 4 feet thick, separated by a thin layer of clay.

KARST AREAS: The subsurface soil and bedrock in Unit Ur contain caves, pinnacles, and solution enlarged joints. Chemical weathering of bedrock by infiltrating surface water has formed a network of underground openings.

Sinkholes have formed in the area when the soil roofs of underground openings have gradually weakened and collapsed to form sinkholes on the land surface. Widely scattered sinkholes are present over the entire unit. There are also areas where clusters of sinks occur, indicating intense karst activity in the bedrock. Examples of these clusters occur near Sparta, Nixa, and the Springfield Municipal Airport.

BEDROCK: Massive cherty limestone which contains large solution enlarged joints and bedding planes. Caves in limestone are numerous. The bedrock surface in this unit can be highly variable due to the pinnacled surface produced by weathering.

ENGINEERING GEOLOGY: The engineering geology of the unit is affected by several factors:

a. <u>Weathering of soil and bedrock in karst areas</u>: The effects of weathering on soil and bedrock in karst areas cannot be ignored in planning for future developments. Catastrophic collapse can occur beneath lakes and lagoons. Homes situated in sinkholes which have been leveled or filled can be flooded by slowly draining surface water. Excavations for foundation footings can encounter a pinnacled uneven bedrock surface and solution enlarged openings in the bedrock.

Development in karst areas can be done but unusual engineering problems and expensive remedial treatment should be expected.

Karst areas have underground drainage systems connected by networks of various sized openings. Liquid pollutants from lagoons, treatment plants, and landfills that enter the networks of underground openings can spread rapidly and contaminate groundwater in the karst bedrock and affect springs and water wells.

b. Engineering features of soil: Blocky structure and light density. Much of the residual clay in this unit has a blocky structure that is caused by the iron element in the soil acting as a binding agent between clay particles. The cracks between small blocks of clay increase the permeability of the soil and decrease soil density. When the clay dries or is exposed to air, it breaks down into blocky sand-size pieces. In this state the clay behaves more like a silt or sand than a clay.

c. Chert residuum in soil: The large amount of chert gravel and boulders in the soil increases permeability. A layer of chert gravel or a relict chert bed that has numerous fractures can be an avenue for rapid lateral movement of water.

LAKES: This unit is not favorable for lakes due to the permeable nature of the soil and bedrock, and the possibility of a sink or cave collapse in the lake basin. The cost of compensating for soil and bedrock conditions would make most lakes too expensive to build.

Small ponds of 1 acre or less can be made to hold water if the soil exposed in the pond basin is compacted by a sheeps foot or rubber tired roller. Clay should be very moist when compacted. Gravel and chert beds exposed inside the pond basin should be removed and replaced by clayey soil.

There has been some success in sealing leaking ponds in the residual soil (Unit Ur) by treating the soil with chemicals such as soda ash or trisodium polyphosphate. The chemical breaks down the blocky structure of the soil and destroys the small cracks between the blocks. It should be spread over the red soil at the rate of 1 pound per 5 square feet of surface area; the surface is then disked and compacted.

Ponds in this unit often behave differently in their ability to hold water. One pond may be dry while a hundred yards away another pond may hold water, possibly because of the manner in which the ponds were constructed. Soil in the basin of a pond holding water may have been disked and compacted.

LAGOONS: To prevent leakage in lagoons, it may be necessary to chemically treat soil in the lagoon floors and sides or, if the soil contains large amounts of gravel, the lagoons can be lined with a clay blanket or plastic liner.

Deep excavations for lagoons may encounter numerous permeable chert layers and/or bedrock pinnacles resulting in expensive sealing costs.

LANDFILLS: Unit Ur is not favorable for landfills, especially in karst areas, because of permeable soil and bedrock. There are exceptions though such as the hilltops overlooking the Eureka Springs Escarpment in northern Greene County, where it is possible to develop suitable landfills. These hilltops are underlain by a 40-foot (or thicker) layer of Northview Shale. The downward migration of landfill leachates is blocked by this relatively impermeable shale. Leachates move along the top of the shale and emerge on the hillsides where it can be captured by conduit trenches and directed to lagoons. Landfills located on the hilltops require careful planning. Some of these areas are not practical to use because of the rugged terrain.

Other possible landfill sites in Unit Ur would be where the residual soils are more than 35 feet thick. A testing and drilling program would be needed on these sites to determine soil permeability at various depths, presence of caves, depth to ground water, and direction of groundwater movement. Engineering plans should provide for leachate drains in bottoms of landfill trenches so that the leachates can drain laterally to lagoons on the surface.

RECEIVING STREAMS: Streams in Unit Ur are in two categories:

a. Wet weather streams: Dry most of the year, and flow only during wet periods. These streams are usually near the crest of the watershed.

b. Losing streams: Lose their flow into the underlying permeable bedrock or soil. Thus pollutants entering losing streams can also enter openings in the bedrock that lead to caves or passageways which may extend for miles. Once in these passages, liquid waste may travel long distances contaminating the ground water it comes in contact with.

Most losing streams (which may be located in any segment of the watershed) are tributaries to streams in Unit Vb.

UNIT Uc

Upland valleys with colluvial soil over residual soil (fig. 28).

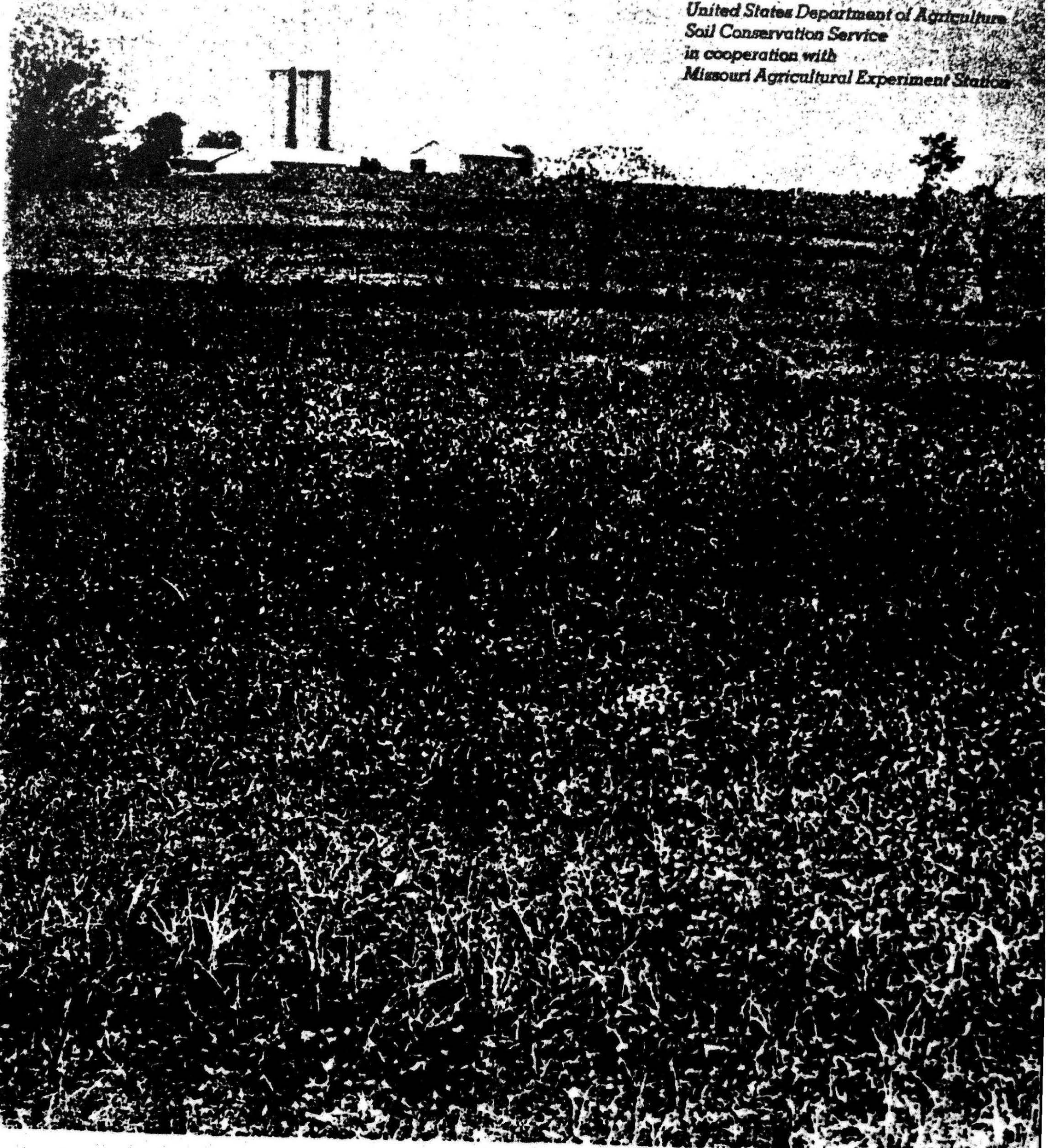
TOPOGRAPHIC SETTING: Upland valleys with gentle sloping sides. Valleys have several different shapes which appear to be influenced by weathering of the underlying bedrock and flat topography. Some valleys are bowl shaped while others are long, narrow, channel-like valleys. Sides of the valleys range from gently sloping to almost flat.

Reference 2

Soil Survey of

GREENE AND LAWRENCE COUNTIES, MISSOURI

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Missouri Agricultural Experiment Station



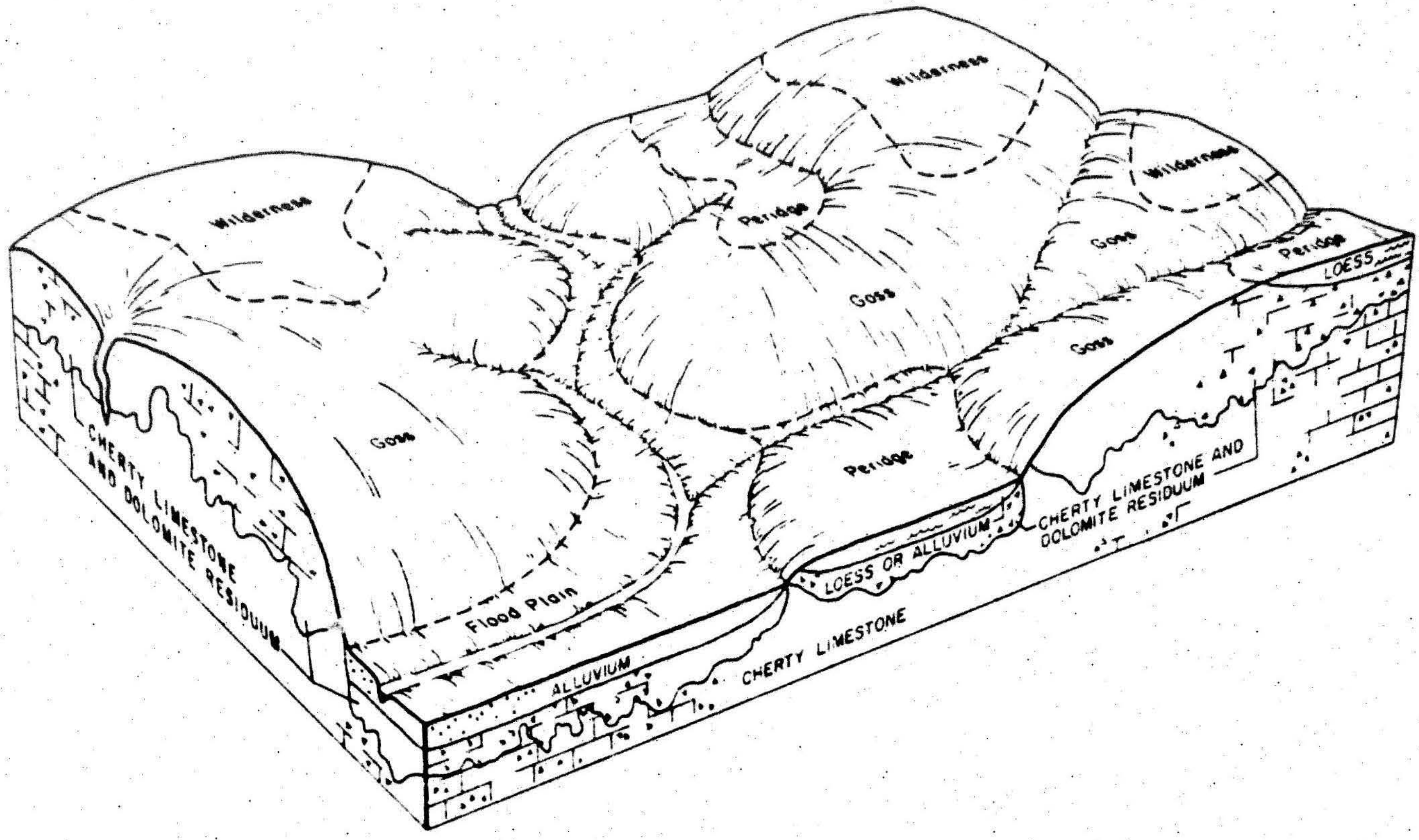


Figure 2.—Typical pattern of soils in the Goss-Wilderness-Peridge association.

upper part of the subsoil are relatively chert-free are well suited to intertilled row crops and small grain.

All of the common grain, forage, and wood crops, including such high value trees as black walnut, grow well on Peridge soils and on the Cedargap and Huntington soils of minor extent. Most of the soils on cherty uplands and some of the soils on terraces and flood plains have low available water capacity. The remaining soils have high or moderate available water capacity. The root zone of some soils is limited by the fragipan at a depth of 15 to 36 inches or by limestone bedrock at a depth of less than 20 inches. Stony or very stony areas and areas of Rock outcrop are common. The main management concerns are droughtiness, the hazard of erosion, and flooding of the bottom lands. Windthrow hazard is a concern of management in woodland areas dominated by soils that have a moderately deep or shallow root zone.

The Goss, Wilderness, and Peridge soils are suited to sanitary facilities and building site development. Major limitations are wetness and slope.

2. Pembroke-Eldon-Creldon association

Deep, well drained and moderately well drained, gently sloping to strongly sloping soils; on uplands and terraces

This association consists of broad upland ridges, narrow flood plains, and terraces (fig. 3). In places, a few gently sloping to moderately steep, stony and rocky areas and escarpments are adjacent to the flood plains and terraces. Sinkholes range from a few to many. Slope of the major soils ranges from 2 to 14 percent.

This association makes up about 23 percent of Greene County and 2 percent of Lawrence County, or about 14 percent of the survey area. Pembroke soils make up about 25 percent of this association, Eldon soils 20 percent, Creldon soils 18 percent, and soils of minor extent 37 percent.

The Pembroke soils are on the tops, sides, and in slight depressions of ridges on uplands and terraces. These soils are deep, well drained, and gently sloping. They formed in residuum weathered from cherty limestone and in thin loess or alluvium and the limestone residuum. Typically, the surface layer is dark brown silt loam about 8 inches thick. The subsoil to a depth of about 72 inches is reddish brown and yellowish red silty clay loam in the upper part; red, mottled silty clay loam in the middle part; and dark red cherty clay in the lower part.

The Eldon soils are on convex sides and tops of ridges on uplands. These soils are deep, well drained, and gently sloping to strongly sloping. They formed in residuum weathered from cherty limestone. Typically, the surface layer is dark brown cherty silt loam about 10 inches thick. The subsoil to a depth of 72 inches is reddish brown very cherty silty clay loam in the upper part; dark red very cherty silty clay in the middle part; and dusky red clay in the lower part.

The Creldon soils are on the tops and sides of ridges on uplands. These soils are deep, moderately well drained, and gently sloping. They formed in thin loess and residuum weathered from cherty limestone. Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsoil above the fragipan is about 15 inches thick. The upper part is dark brown, mottled silty clay loam, and the lower part is grayish brown and dark grayish brown, mottled silty clay loam. The fragipan is mottled red, grayish brown, and dark gray silty clay loam and cherty silty clay loam about 12 inches thick. The subsoil below the fragipan to a depth of 67 inches is dark red cherty silty clay and yellowish brown and dark red cherty clay.

Of minor extent in this association are Keeno, Cedargap, Newtonia, Lanton, Hepler, and Gerald soils. The gently sloping and moderately sloping, moderately well drained Keeno soils; very gently sloping, well drained Newtonia soils; and nearly level, somewhat poorly drained Gerald soils are on ridges on uplands. The nearly level, well drained and somewhat excessively drained Cedargap soils and somewhat poorly drained Lanton soils are on flood plains. The nearly level, somewhat poorly drained Hepler soils are on low terraces.

About 85 percent of the areas in this association is used for grasses and legumes. Most of the remaining areas are used for cultivated small grain and row crops, and 5 percent is in second growth woodland. The forage crops and most of the grain crops are fed to beef and dairy cattle. Wheat and soybeans are sold as cash grain.

Except for a few stony areas and small scattered areas of Rock outcrop, the soils in this association are well suited to grasses, legumes, and small grain. The gently sloping soils on uplands that are relatively chert-free in the surface layer and upper part of the subsoil and soils on the wider flood plains and terraces are well suited to cultivated crops.

All of the common forage and grain crops grow well on Creldon and Pembroke soils and on the Newtonia, Gerald, and Lanton soils of minor extent. Most of these

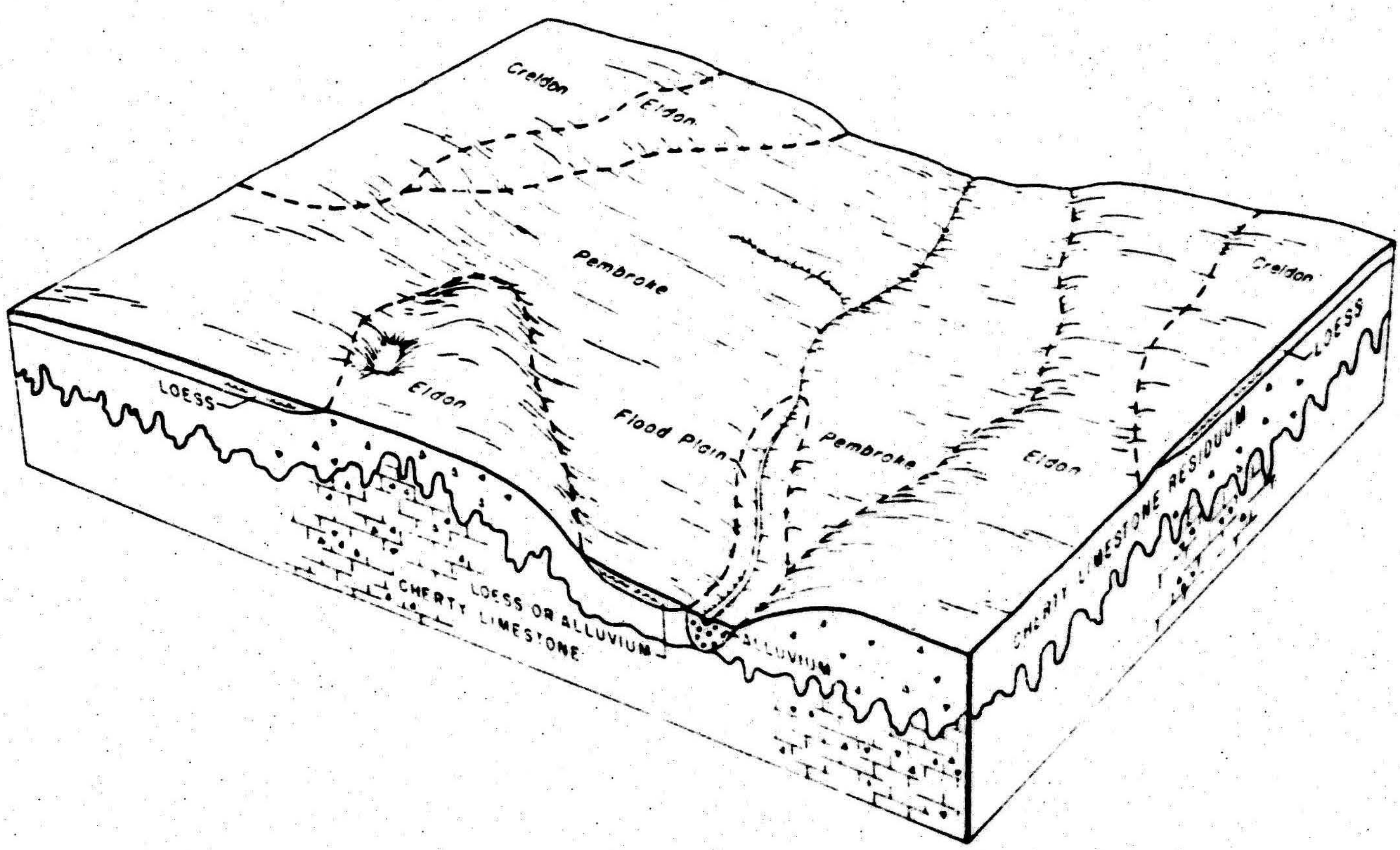
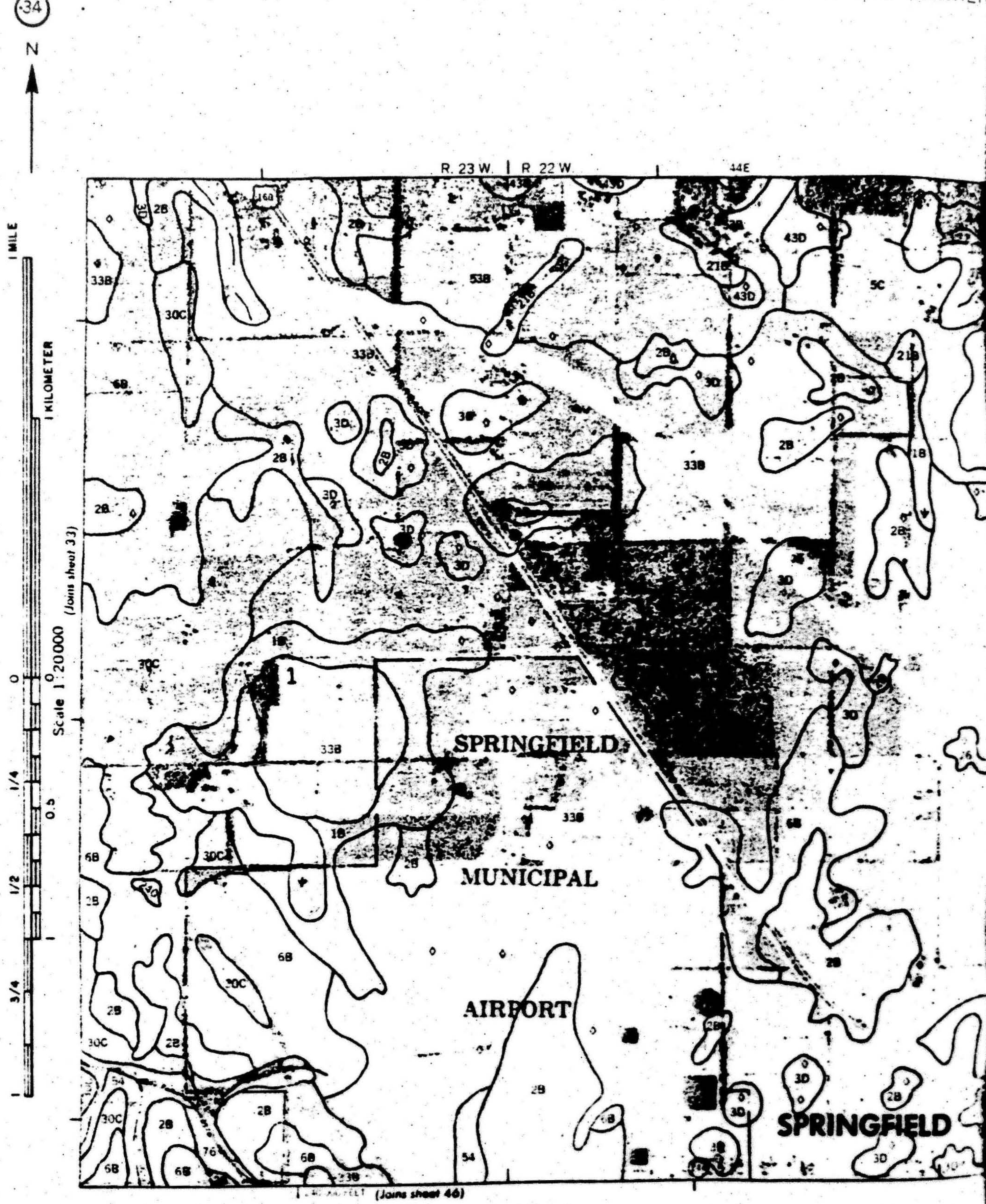


Figure 3.—Typical pattern of soils in the Pembroke-Eldon-Creldon association.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cultivated row crops is grown. Minimum tillage coupled with highly specialized management of row crops, small grain, and meadow crops grown in rotation also effectively control erosion. The proper utilization of crop residue helps maintain organic matter content and good tilth and increases available water.

Grasses and legumes grown for pasture and hay effectively help to control erosion. Overgrazing pasture increases the growth of weeds and reduces the yield of grasses and legumes. Pasture quality and soil condition, as well as forage production, can be improved by proper stocking, pasture rotation, timely deferment of grazing, and fertilization according to soil test.

This soil is suited to building site development and to most onsite waste disposal systems if proper design and installation procedures are used. Moderate shrink-swell potential and moderate permeability are factors to be considered in design. Septic tank absorption fields need to be enlarged to compensate for the moderate permeability. Community sewers should be used if available. Foundations of buildings and basement walls should be designed and constructed with adequate reinforcement to prevent structural damage from the shrinking and swelling of this soil. This soil does not have sufficient strength to support vehicular traffic, but this can be corrected by adding suitable base material. Embankments for farm ponds or lakes are difficult to pack and seal. Ponds commonly fail to hold water because of seepage or other reasons. Deep wells are dug in some places, and the water is piped to livestock or used for other purposes.

This Newtonia soil is in capability subclass IIe.

2B—Pembroke silt loam, 1 to 5 percent slopes. This deep, gently sloping, well drained soil is on the tops and sides and in slight depressions of ridges on uplands and stream terraces. Individual areas range from about 10 acres to several hundred acres.

Typically, the surface layer is dark brown silt loam about 8 inches thick. The subsoil to a depth of about 72 inches is reddish brown and yellowish red, friable silty clay loam in the upper part; red, mottled, firm silty clay loam in the middle part; and dark red, very firm cherty clay in the lower part. The surface layer in eroded areas or spots is brown or reddish brown silty clay loam. In places, the subsoil is cherty in the 30- to 40-inch zone. Also in places, the upper 20 inches of the subsoil is silty clay. Short steep slopes or terrace escarpments adjacent to flood plains and other slope breaks have gradient of more than 5 percent.

Included with this soil in mapping and making up 10 percent of mapped areas are Creldon and Eldon soils. These soils are on positions similar to those of the Pembroke soils. The Creldon soils have a fragipan; Eldon soils are cherty and steeper.

This Pembroke soil is moderately permeable, runoff is medium, and available water capacity is high. The shrink-swell potential at a depth of more than 30 to 50 inches is moderate. The response to soil amendments is very good.

Most areas of this soil are in cropland and pastureland. A large acreage is used for dwellings or other urban development. Moderate susceptibility to erosion is a concern of management if this soil is used for cultivated crops. If row crops dominate the crop sequence, grassed waterways and field terraces are commonly used to help control erosion. In rotations that include small grain and meadow, minimum tillage combined with other highly specialized management practices effectively control erosion. The proper use of residue helps maintain good tilth and increase available water.

Grasses and legumes grown for hay and pasture effectively and economically help to control erosion. Overgrazing increases the growth of weeds, reduces the yield of grasses and legumes, and increases surface runoff. Proper stocking rates, pasture rotation, and the timely deferment of grazing along with fertilization as needed improve pasture quality and forage production.

This soil is suited to trees. The trees can be grown for building material, fuel, shade, landscaping, or other uses. Both hardwoods and conifers thrive, and concerns in management are few and easy to remedy.

This soil is suited to building site development and to most onsite waste disposal systems if proper design and installation procedures are used. Moderate shrink-swell potential at a depth of 30 to 40 inches is the main factor to be considered in the design of buildings. Community sewers should be used if available. Foundations of buildings and basement walls should be designed and constructed with adequate reinforcement to prevent structural damage caused by shrinking and swelling of this soil. This soil does not have sufficient strength to support vehicular traffic, but this can be overcome by adding suitable base material. Embankments for farm ponds or lakes are difficult to pack and seal. Ponds commonly fail to hold water because of seepage or other reasons. Deep wells are dug in places, and the water is piped to livestock or used for other purposes.

This Pembroke soil is in capability subclass IIe and woodland suitability subclass 3o.

3D—Eldon cherty silt loam, 5 to 14 percent slopes. This deep, moderately sloping and strongly sloping, well drained soil is on the convex sides and the tops of ridges on uplands. Individual areas range from about 10 acres to 100 acres or more. Many areas have a few to numerous sinkholes, and some areas have a few stones on the surface.

Typically, the surface layer is dark brown cherty silt loam about 10 inches thick (fig. 10). The subsoil to a depth of about 72 inches is reddish brown, friable and firm very cherty silty clay loam in the upper part; dark red, firm very cherty silty clay in the middle part; and dusky red, very firm clay in the lower part. In places, the surface layer is less than 6 inches thick, or it is brown.

The clay content of the upper part of the subsoil averages less than 35 percent in places. Side slopes near the low perimeter of some areas, especially the side slopes of sinkholes, have scarped edges and slope of more than 14 percent; some of these areas have bedrock at a depth of 40 to 60 inches. Also, some small areas are stony.

Included with this soil in mapping and making up as much as 5 percent of mapped areas are Keeno, Creldon, Gasconade, and Pembroke soils. Small areas of Rock outcrop are also included. The Creldon and Keeno soils have a fragipan and are on ridgetops. The shallow Gasconade soils are on the slope breaks, and Rock outcrop is on slope breaks and side slopes of sinkholes. The Pembroke soils do not have chert and are in gently sloping areas.

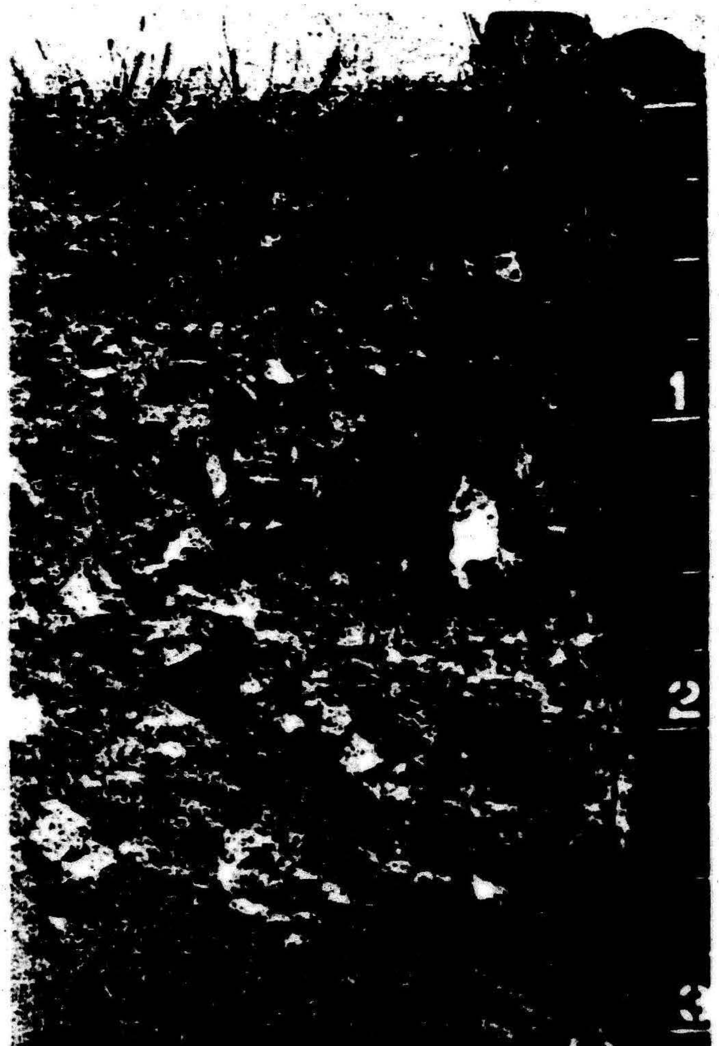

Figure 10.—Profile of Eldon cherty silt loam, 5 to 14 percent slopes. Note the decrease in chert content in the lower part of the subsoil. Depths are shown in feet.

This Eldon soil is moderately permeable, runoff is medium, and available water capacity is low. The shrink-swell potential is moderate. The response to soil amendments is good.

Most areas of this soil are in pastureland and hayland. The soil is suited to grasses, alfalfa or other legumes, and small grain forage. It is suited to grain crops if erosion is controlled. The moderately sloping areas of this soil are suitable for soybeans, sorghums, or corn if these crops are grown in rotations that include several years of pasture or hay crops. The proper use of crop residue and cover crops and green manure crops in the cropping sequence help maintain the organic matter content, provide good tilth, and increase available water. Terraces, grassed waterways, minimum tillage, and farming on the contour help to control erosion and retard runoff.

Grasses and legumes grown for hay and pasture effectively control erosion. Tillage operations should be restricted to stand establishment, renovation, and reseeding. New stands need to be seeded early to insure good ground cover. Nurse crops of small grain help provide cover for seedings late in fall. Overgrazing pasture reduces the yield of grasses and legumes and increases the growth of weeds. Pasture quality, soil condition, and forage production can be improved by proper fertilization, controlled stocking rates, pasture rotation, and timely deferment of grazing. Weedy areas should be clipped in June and August. Chemical sprays help control broad-leaved weeds.

This soil is suited to building site development and to some onsite waste disposal systems if proper design and installation procedures are used. Factors to be considered are slope of more than 8 percent, moderate shrink-swell potential in the clayey subsoil, and chert and a few stones on the surface. Septic tank absorption fields should be enlarged to compensate for the moderate permeability in this soil. Slope can be modified by grading for sewage lagoons. Community sewers should be used if available. Structural damage to basement walls and foundations of buildings, caused by shrinking and swelling in this soil, can be prevented if the basement walls and foundations are properly designed and constructed with adequate reinforcement. Local roads and streets should have suitable base material and be properly drained by side ditches and culverts to prevent damage from shrinking and swelling and frost action. Embankments for farm ponds and sewage lagoons are very difficult to pack and seal. Because the limestone residuum under the soils in this unit is thin, porous, and transmits water freely, farm ponds must be properly constructed to insure that water will be retained (*12*). Porosity and permeability of this soil can be reduced by use of compaction equipment, artificial sealants, and deflocculating agents.

This Eldon soil is in capability subclass IVs.

5C—Wilderness cherty silt loam, 2 to 9 percent slopes. This deep, gently sloping and moderately

Available water capacity is high in the Freeburg soils and moderate in the Alsup soils. A perched water table is at a depth of 1.5 to 4 feet from November to May in most years. The shrink-swell potential is high in the Alsup soils and moderate in the Freeburg soils. The response to soil amendments is good.

Most areas of these soils are in cropland or pastureland. Some areas are in woodland. A small acreage is used for small grain and row crops. These soils are suited to grasses and legumes. Concerns of management are the high susceptibility to erosion and wetness. Also of concern is occasional flooding in some areas of gently sloping Freeburg soils from April to July if they are cropped. Surface runoff from wooded or grass-covered adjoining upland can be controlled by diversion terraces. Grass waterways, land smoothing, field terraces, and minimum tillage help to control erosion. The proper utilization of crop residue provides good tilth, maintains the organic matter content, and increases available water.

Grasses and legumes grown for pasture and hay effectively control erosion. Tillage operations should be restricted to stand establishment, renovation, and reseeding. New stands need to be seeded early to establish good ground cover before the end of the growing season. Nurse crops of small grain provide fair to good fall and winter cover for late seedings. Overgrazing or grazing when these soils are wet reduces the stand of grasses and legumes, increases the growth of weeds, and causes poor tilth and compaction. Restricting the use of pasture in wet periods, fertilization as needed, proper stocking rates, pasture rotation, and timely deferment of grazing improve plant production, pasture quality, and soil condition.

These Freeburg and Alsup soils are suited to trees, and stands of hardwoods are in some areas. Concerns of management are few and easy to remedy. The growth rate is good. The production and quality can be improved by the removal of undesirable trees, selective cutting, protection from fire, and controlled grazing.

These soils are generally not suited to building site development and onsite waste disposal in areas that are subject to occasional flooding. Onsite investigation and previous flooding history are needed to determine whether the area is free from flooding or subject to flooding. In areas that are protected or free from flooding, factors to consider in the design of structures are wetness, high shrink-swell potential, and moderately slow permeability. Slope is a concern for sewage lagoons. Areas subject to surface runoff from adjacent areas can be protected with diversion terraces. Properly constructed sewage lagoons function adequately if protected from flooding, the bottom of the lagoon is sealed to prevent pollution of the ground water, and the site is graded to modify the slope. Community sewers should be used if available. The footings, foundations, and basement walls of buildings need to be designed and constructed with adequate reinforcement to prevent structural damage from shrinking and swelling of the soil. Drain tiles help prevent damage from excessive wetness. Local roads and streets should be graded to shed water and side ditches and culverts constructed to lower the water table and prevent damage caused by frost action and shrinking and swelling. Suitable base material needs to be added to overcome low strength.

These soils are in capability subclass IIIe; woodland capability subclass is 3o for Freeburg soils and 4o for Alsup soils.

33B—Keeno and Eldon cherty silt loams, 2 to 5 percent slopes. This map unit consists of deep, gently sloping, moderately well drained Keeno soils and well drained Eldon soils on the convex tops and side slopes of ridges on uplands. The Keeno soils are at a higher elevation and dominantly have slope of 2 or 3 percent; the Eldon soils are at a lower elevation and mainly have slope of 4 or 5 percent. The extent of Keeno and Eldon soils in individual areas varies widely from place to place; in some areas only one of these soils is present. Generally, areas are about 40 percent Keeno soils and 30 percent Eldon soils. Individual areas are irregular in shape and range from about 10 acres to 100 acres or more. Most areas have a few to many sinkholes. In some areas, a few stones are on the surface.

Typically, the surface layer of the Keeno soil in this unit is dark brown cherty silt loam about 11 inches thick. The subsoil above the fragipan is reddish brown and about 17 inches thick. The upper part is friable very cherty silt loam, and the lower part is friable very cherty silty clay loam. The fragipan is about 11 inches thick. It is mottled, multicolored very cherty silt loam overlying very cherty silty clay loam. The subsoil below the fragipan to a depth of 60 inches is dark red, mottled, very firm cherty clay. In some places, the fragipan is intermittent or very weakly developed. Side slopes have gradient of more than 5 percent in some places.

Typically, the surface layer of the Eldon soil in this unit is dark brown cherty silt loam about 8 inches thick. The subsoil to a depth of about 72 inches is brown, friable cherty silty clay loam in the upper part; red, mottled, firm very cherty silty clay loam in the middle part; and dark red and dusky red, very firm very cherty clay over cherty clay in the lower part. In places, the dark surface layer is less than 6 inches thick or is brown. In places, the average clay content in the upper part of the subsoil is less than 35 percent. The depth to bedrock is 40 to 60 inches on some hilltop knolls and low side slopes. The sides of some sinkholes have rock-scarped edges or slope of more than 5 percent, or both of these.

Included with these soils in mapping and making up as much as 10 percent of mapped areas are Pembroke soils; making up as much as 5 percent are Creldon, Gasconade, and Hoberg soils and Rock outcrop. The Creldon and Hoberg soils are on the tops of broad ridges at a relatively high elevation. The Pembroke soils are adjacent to drainageways and in slight depressions on the tops and foot slopes of ridges. The shallow Gasconade soils and Rock outcrop are on slope breaks. Creldon and Hoberg soils have a fragipan; Hoberg and Pembroke soils have less chert in the upper part of the subsoil than the major soils.

Permeability in the Keeno soils is moderately rapid above the fragipan and slow in the fragipan. The Eldon soils are moderately permeable. The available water capacity is low, and surface runoff is medium for both soils. The Keeno soils have a perched water table at a depth of 2.5 to 4.0 feet from December through March in most years and have a limited root zone because of a fragipan at a depth of 18 to 36 inches. The Eldon soils have moderate shrink-swell potential. The response to soil amendments is good in both soils.

Most areas of these soils are in pastureland and hayland. Some areas are in cropland. These soils are suited to small grain, grasses, and legumes as grain and forage crops. Soybeans, sorghums, or corn can be grown safely if erosion is controlled. Erosion can be controlled in row crops by including several years of pasture or hay in the crop rotation. The proper use of crop residue and including cover crops and green manure crops in the cropping system help to maintain organic matter content, provide good tilth, and increase available water. Terraces, grassed waterways, minimum tillage, and farming on the contour help to control erosion and retard runoff.

Grasses and legumes grown for hay and pasture effectively control erosion. Overgrazing pasture reduces the forage yield and increases the growth of weeds. Plant production, forage quality, and soil condition can be improved by proper fertilization, controlled stocking rates, pasture rotation, timely deferment of grazing, and the use of good management.

These soils are suited to building site development and to some onsite waste disposal systems. Wetness and restricted permeability in the Keeno soils, moderate shrinking and swelling in the Eldon subsoil, and the chert content and stones on the surface in both soils are factors to be considered in the design of dwellings and sanitary facilities. Increasing the thickness of the absorption field by properly constructing a mound of desirable material helps make the Keeno soils suitable for septic tank absorption fields (*3*). In Eldon soils the absorption field needs to be enlarged to compensate for the moderate permeability. Community sewers should be used if available. Structural damage to basement walls and foundations of buildings because of moderate shrinking and swelling of the soil can be prevented by proper design and the use of adequate reinforcement in structures. Grading local roads and streets and properly draining them with side ditches and culverts help prevent damage from frost action and shrinking and swelling. Because the limestone residuum under the soils in this unit is thin and porous and transmits water freely, farm ponds must be properly constructed to insure that water will be retained (*12*). Compaction equipment, artificial sealants, and deflocculating agents can be used to reduce the porosity and permeability of these soils.

These Keeno and Eldon soils are in capability subclass IVs.

35D—Clarksville-Nixa cherty silt loams, 5 to 14 percent slopes. This map unit consists of deep, moderately sloping and strongly sloping, somewhat excessively drained Clarksville soils and moderately sloping, moderately well drained Nixa soils on the sides and tops of ridges on uplands. Clarksville soils dominate the side slopes at a relatively lower elevation, and Nixa soils dominate the ridgetops. Generally, areas are about 60 percent Clarksville soils and 20 percent Nixa soils. Individual areas range from about 20 acres to several hundred acres. Large areas are dissected by many upland drainageways, narrow flood plains, and terraces. Some areas have rock-scarped edges adjacent to stream bottoms and terraces.

Typically, the surface layer of the Clarksville soil is very dark grayish brown cherty silt loam about 4 inches thick. The subsurface layer is yellowish brown cherty silt loam about 5 inches thick. The subsoil to a depth of 72 inches is brown, friable very cherty silt loam in the upper part; strong brown, mottled, firm very cherty silty clay loam in the middle part: and dark red, mottled, very firm very cherty clay in the lower part. Escarpments, breaks, and some lower side slopes have gradient of more than 14 percent. Parts of some areas are stony.

Typically, the surface layer of the Nixa soil is very dark grayish brown cherty silt loam about 4 inches thick. The subsurface layer is grayish brown very cherty silt loam about 4 inches thick. The subsoil above the fragipan is yellowish brown, friable very cherty silt loam about 11 inches thick. The next layer, immediately above the fragipan, is brown, friable very cherty silt loam 3 inches thick. The fragipan is reddish brown and yellowish brown, mottled, firm very cherty silty clay loam about 15 inches thick. The subsoil below the fragipan to a depth of 72 inches is dark red and dusky red, mottled, very firm very cherty clay. In a few areas, slope is less than 5 percent. Some areas are stony, and a few areas have bedrock at a depth of less than 60 inches and have more clay in the lower part of the subsoil than typical.

Included with these soils in mapping and making up 5 to 10 percent of mapped areas are Goss and Viraton soils and Rock outcrop. The Goss soils have more clay than the major soils and are on the tops of ridges. The Viraton soils have more silt and less chert in the upper part of the subsoil and are on the top and upper side slopes of ridges. Rock outcrop is on the slope breaks.

Permeability is moderately rapid in the Clarksville soils and very slow in the Nixa soils. The available water capacity is low, and runoff is medium in both soils. A fragipan is at a depth of 12 to 24 inches in the Nixa soils. The fragipan limits the root zone. The response to soil amendments in the Clarksville soils is good but is only fair in the Nixa soils.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay <2mm	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
1B---------------	0-10	10-24	1.30-1.55	0.6-2.0	0.15-0.24	5.6-6.5	Low-----------	0.37	5	5	1-3
Newtonia	10-21	20-35	1.40-1.70	0.6-2.0	0.16-0.22	5.1-6.5	Moderate-----	0.37			
	21-27	27-35	1.45-1.70	0.6-2.0	0.18-0.22	5.1-6.0	Moderate-----	0.32			
	27-54	32-45	1.35-1.65	0.6-2.0	0.12-0.20	5.1-6.0	High----------	0.32			
	54-72	32-45	1.35-1.65	0.6-2.0	0.12-0.20	5.1-7.3	High----------	0.32			
2B---------------	0-8	12-27	1.10-1.30	0.6-2.0	0.18-0.23	4.5-6.0	Low-----------	0.32	4	6	2-3
Pembroke	8-46	27-35	1.20-1.40	0.6-2.0	0.14-0.19	4.5-6.0	Low-----------	0.32			
	46-72	40-70	1.40-1.60	0.6-2.0	0.12-0.18	4.5-6.0	Moderate-----	0.32			
3D---------------	0-10	7-27	1.20-1.40	2.0-6.0	0.13-0.18	5.1-6.0	Low-----------	0.24	2	8	.5-2
Eldon	10-31	35-50	1.40-1.50	0.6-2.0	0.03-0.08	4.5-6.0	Moderate-----	0.24			
	31-72	35-50	1.40-1.55	0.6-2.0	0.10-0.14	5.1-6.5	Moderate-----	0.24			
5C---------------	0-10	18-27	1.20-1.45	2.0-6.0	0.07-0.12	4.5-7.3	Low-----------	0.28	2	8	.5-2
Wilderness	10-21	25-35	1.30-1.50	0.6-2.0	0.03-0.10	4.5-6.0	Low-----------	0.28			
	21-56	20-35	1.70-2.00	0.06-0.2	---	4.5-6.0	Low-----------	0.28			
	56-72	40-70	1.50-1.70	0.2-0.6	---	4.5-6.0	Moderate-----	0.28			
6B---------------	0-9	15-25	1.20-1.50	0.6-2.0	0.22-0.24	4.5-7.3	Low-----------	0.37	4	5	1-3
Creldon	9-24	35-45	1.30-1.50	0.6-2.0	0.12-0.17	4.5-6.5	Low-----------	0.37			
	24-36	25-35	1.50-1.70	0.06-0.2	0.07-0.14	3.6-5.0	Low-----------	0.37			
	36-67	35-70	1.10-1.40	0.6-2.0	0.05-0.10	3.6-6.0	Moderate-----	0.37			
9B---------------	0-7	15-25	1.30-1.50	0.6-2.0	0.15-0.19	4.5-7.3	Low-----------	0.37	4	6	.5-2
Needleye	7-21	25-35	1.50-1.70	0.2-0.6	0.12-0.16	3.6-5.5	Low-----------	0.37			
	21-29	25-35	1.30-1.50	0.2-0.6	0.08-0.12	3.6-5.0	Low-----------	0.37			
	29-38	20-30	1.10-1.40	0.06-0.2	0.01-0.05	3.6-6.0	Low-----------	0.28			
	38-72	40-75	1.10-1.40	0.2-0.6	0.03-0.08	3.6-6.0	Moderate-----	0.28			
10---------------	0-12	15-25	1.20-1.50	0.2-0.6	0.22-0.24	3.6-6.0	Low-----------	0.43	4	5	.5-2
Bado	12-16	30-40	1.30-1.50	0.06-0.2	0.12-0.17	3.6-5.5	Moderate-----	0.43			
	16-28	35-55	1.30-1.50	0.06-0.2	0.09-0.11	3.6-5.5	High----------	0.43			
	28-51	25-35	1.50-1.70	<0.06	0.07-0.10	3.6-5.5	Moderate-----	0.43			
	51-76	35-70	1.30-1.60	0.06-0.2	0.05-0.10	3.6-6.0	Moderate-----	0.43			
11B---------------	0-13	25-35	1.30-1.50	0.2-0.6	0.21-0.24	5.6-7.3	Moderate-----	0.37	3	4	3-4
Sampsel	13-66	35-48	1.40-1.60	0.06-0.2	0.11-0.13	5.6-7.8	High----------	0.37			
16B---------------	0-11	10-20	1.40-1.55	2.0-6.5	0.16-0.18	5.1-6.5	Low-----------	0.28	4	3	1-3
Barco	11-37	18-35	1.40-1.60	0.6-2.0	0.12-0.16	4.5-6.5	Moderate-----	0.28			
	37-60	---	---	---	---	---	-------------	----			
21B---------------	0-9	10-20	1.25-1.45	0.6-2.0	0.15-0.24	4.5-6.5	Low-----------	0.37	5	5	1-3
Peridge	9-45	20-34	1.25-1.45	0.6-2.0	0.13-0.22	4.5-6.0	Low-----------	0.32			
	45-72	40-60	1.15-1.35	0.6-2.0	0.09-0.18	4.5-6.0	Moderate-----	0.24			
23B---------------	0-11	12-18	1.20-1.45	2.0-6.0	0.16-0.18	5.1-6.5	Low-----------	0.24	4	3	.5-2
Bolivar	11-32	20-35	1.30-1.50	0.6-2.0	0.12-0.16	4.5-6.0	Moderate-----	0.32			
	32-60	---	---	---	---	---	-------------	----			
24---------------	0-14	15-25	1.30-1.50	0.6-2.0	0.16-0.24	5.1-7.3	Low-----------	0.43	4	6	.5-1
Parsons	14-66	35-60	1.40-1.70	<0.06	0.14-0.22	5.1-7.8	High----------	0.43			
26D*---------------	0-10	5-20	1.30-1.65	2.0-6.0	0.12-0.16	5.1-6.5	Low-----------	0.32	2	3	1-2
Collinsville	10-13	5-20	1.30-1.65	2.0-6.0	0.09-0.13	5.1-6.5	Low-----------	0.20			
	13	---	---	---	---	---	-------------	----			
27D*---------------	0-13	12-20	1.20-1.40	2.0-6.0	0.13-0.18	5.1-6.5	Low-----------	0.24	2	8	<2
Basehor	13	---	---	---	---	---	-------------	----			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
30C---------------- Keeno	0-17	15-25	1.30-1.60	2.0-6.0	0.06-0.15	4.5-7.3	Low-----------	0.24	4	7	1-3
	17-30	25-35	1.50-1.80	2.0-6.0	0.02-0.10	3.6-5.5	Low-----------	0.24			
	30-45	25-35	1.60-1.90	0.06-0.2	0.01-0.05	3.6-5.5	Low-----------	0.24			
	45-72	40-80	1.10-1.40	0.6-2.0	0.04-0.10	3.6-5.5	Moderate-----	0.24			
32C*:											
Freeburg---------	0-10	12-25	1.20-1.45	0.6-2.0	0.22-0.24	5.6-7.3	Low-----------	0.37	5	6	.5-2
	10-13	27-35	1.40-1.50	0.6-2.0	0.18-0.20	5.1-6.0	Moderate-----	0.37			
	13-34	27-35	1.40-1.50	0.2-0.6	0.15-0.19	4.5-6.5	Moderate-----	0.37			
	34-72	27-32	1.35-1.50	0.2-0.6	0.16-0.20	5.1-6.5	Moderate-----	0.37			
Alsup------------	0-6	20-30	1.20-1.50	0.6-2.0	0.15-0.20	5.1-7.3	Low-----------	0.37	3	6	.5-2
	6-10	35-45	1.20-1.50	0.2-0.6	0.12-0.17	4.5-6.0	Moderate-----	0.37			
	10-33	35-50	1.30-1.50	0.2-0.6	0.10-0.17	3.6-7.3	High----------	0.37			
	33-60	35-50	1.40-1.70	0.2-0.6	0.06-0.12	3.6-7.8	High----------	0.37			
33B*:											
Keeno------------	0-11	15-25	1.30-1.60	2.0-6.0	0.06-0.15	4.5-7.3	Low-----------	0.24	4	7	1-3
	11-28	25-35	1.50-1.80	2.0-6.0	0.02-0.10	3.6-5.5	Low-----------	0.24			
	28-39	25-35	1.60-1.90	0.06-0.2	0.01-0.05	3.6-5.5	Low-----------	0.24			
	39-60	40-80	1.10-1.40	0.6-2.0	0.04-0.10	3.6-5.5	Moderate-----	0.24			
Eldon------------	0-8	7-27	1.20-1.40	2.0-6.0	0.13-0.18	5.1-6.0	Low-----------	0.24	2	8	.5-2
	8-19	35-50	1.40-1.50	0.6-2.0	0.03-0.08	5.1-6.0	Moderate-----	0.24			
	19-72	35-50	1.40-1.55	0.6-2.0	0.10-0.14	5.1-6.5	Moderate-----	0.24			
35D*:											
Clarksville------	0-13	14-20	1.30-1.60	2.0-6.0	0.07-0.12	4.5-6.0	Low-----------	0.28	2	8	1-2
	13-30	28-35	1.40-1.65	2.0-6.0	0.06-0.10	4.5-5.5	Low-----------	0.28			
	30-72	40-75	1.40-1.80	2.0-6.0	0.05-0.08	4.5-5.5	Low-----------	0.28			
Nixa-------------	0-8	5-25	1.30-1.60	0.6-2.0	0.08-0.10	4.5-6.0	Low-----------	0.43	2	8	1-3
	8-22	20-35	1.30-1.60	0.2-0.6	0.08-0.10	4.5-5.5	Low-----------	0.43			
	22-37	20-35	1.40-1.80	<0.06	0.05-0.08	4.5-5.5	Low-----------	0.43			
	37-72	30-50	1.30-1.45	<0.06	0.03-0.06	4.5-5.5	Low-----------	0.37			
40E---------------- Alsup	0-8	20-30	1.20-1.50	0.6-2.0	0.12-0.18	5.1-7.3	Low-----------	0.28	3	8	.5-2
	8-19	35-45	1.30-1.50	0.2-0.6	0.08-0.15	4.5-6.0	Moderate-----	0.28			
	19-34	35-50	1.30-1.50	0.2-0.6	0.08-0.15	3.6-7.8	High----------	0.28			
	34-48	35-50	1.40-1.70	0.2-0.6	0.04-0.10	3.6-7.8	High----------	0.28			
	48-60	---	---	---	---	---	-------------	----			
43D---------------- Goss	0-8	7-27	1.10-1.30	2.0-6.0	0.06-0.17	4.5-7.3	Low-----------	0.24	2	6	1-2
	8-20	20-30	1.10-1.30	2.0-6.0	0.06-0.10	4.5-7.3	Low-----------	0.24			
	20-72	35-60	1.30-1.50	0.6-2.0	0.04-0.09	4.5-6.0	Moderate-----	0.24			
44E*:											
Goss-------------	0-4	7-27	1.10-1.30	2.0-6.0	0.06-0.17	4.5-7.3	Low-----------	0.24	2	6	1-2
	4-9	20-30	1.10-1.30	2.0-6.0	0.06-0.10	4.5-7.3	Low-----------	0.24			
	9-60	35-60	1.30-1.50	0.6-2.0	0.04-0.09	4.5-6.0	Moderate-----	0.24			
Gasconade--------	0-11	35-50	1.35-1.50	0.6-2.0	0.10-0.12	6.1-7.8	Moderate-----	0.20	2	8	2-4
	11	---	---	---	---	---	-------------	----			
45E---------------- Clarksville	0-16	14-20	1.30-1.60	2.0-6.0	0.07-0.12	4.5-6.0	Low-----------	0.28	2	8	1-2
	16-45	28-35	1.40-1.65	2.0-6.0	0.06-0.10	4.5-5.5	Low-----------	0.28			
	45-72	40-75	1.40-1.80	2.0-6.0	0.05-0.08	4.5-5.5	Low-----------	0.28			
50C---------------- Nixa	0-6	5-25	1.30-1.60	0.6-2.0	0.08-0.10	4.5-6.0	Low-----------	0.43	2	8	1-3
	6-18	20-35	1.30-1.60	0.2-0.6	0.08-0.10	4.5-5.5	Low-----------	0.43			
	18-41	20-35	1.40-1.90	<0.06	0.05-0.08	4.5-5.5	Low-----------	0.43			
	41-72	30-50	1.30-1.45	<0.06	0.03-0.06	4.5-5.5	Low-----------	0.37			

See footnote at end of table.

POTENTIAL HAZARDOUS WASTE SITE - SITE INSPECTION REPORT.

II 04 Depth to Groundwater - 75-100' to water table in Mississippian (Upper) aquifer.

II 05 Direction of Groundwater Flow - to the north in general for flow in saturated zone, but flow in karst conduits (above saturated zone) is to the northeast to Ritter West Spring or to the north to the Williams-Fantastic-Bunge Springs Complex.

II 06 Depth to Aquifer of Concern - 5-20' to the top of bedrock (pinnacled bedrock surface)

II 07 Potential Yield of Aquifer - 50 gpm is possible if the wellbore intersects numerous secondary permeability features.

II 08 Sole Source Aquifer - No, the Cambrian-Ordovician aquifer lies below the Northview Formation.

II 10 Recharge Area - Yes, recharge primarily to karst conduits in vadose zone, with minor recharge to the saturated Mississippian aquifer below.

II 11 Discharge Area - No.

VI 01 Permeability of Unsaturated Zone - 10^{-4} to 10^{-3} cm/sec.

VI 02 Permeability of Bedrock - Very permeable.

VI 03 Depth to Bedrock - 5-20'

VI 08 Site Slope - 1-5%

Direction of Site Slope - Site slopes in every direction. It is within a karst plain.
Terrain average slope - 2-3%

VI 14 Description of Site in Relation to Surrounding Topography.
Site is within an internally-drained sinkhole plain. Slopes are generally gentle in the area. The topography becomes rugged along the Little Sac River to the north-northeast.

VII Sources of Information
See HRS References.